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VALIDITY AND RELIABILITY STUDY OF THE RUNNING-BASED ANAEROBIC SPRINT TEST FOR EVALUATING ANAEROBIC POWER PERFORMANCE AS COMPARED TO WINGATE TEST IN INDIAN MALE TRACK AND FIELD SPRINTERS

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Abstract:
Aim: To investigate the criterion validity and relative and absolute reliability of the running-based anaerobic sprint test (RAST) in Indian male track and field sprinters. **Material and Methods**: Thirty five (n = 35) Indian male sprinters participating in 100m, 200 m and 400 m sprint racing randomly performed RAST and Wingate test as the criterion measure of anaerobic power with one trial each on two separate days. Data were analyzed using the Student's paired *t*-test, Pearson's linear correlation test, intra-class correlation coefficients and Bland and Altman's plots. **Results**: Criterion validity was strong and positively significant for average power (r = 0.644, p < 0.000); however, the RAST significantly overestimated maximum and minimum anaerobic power compared to Wingate as revealed by paired t-test. The RAST showed good relative reliability for average power, ICC = 0.628 (0.373 - 0.795: 95% CI) and the higher internal consistency was found only for average anaerobic power value (α = 0.772). In the Bland-Altman

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analyses, linear regression analyses revealed that both means of differences and limits of agreement were found to be low in cases of average and minimum values of anaerobic power and fatigue index and the results were also not found to be statistically significant, resulting in good reliability. **Conclusion**: The RAST is a practicable field test to estimate levels of average anaerobic power of track and field sprinters. Coaches and trainers can use RAST for anaerobic power assessment that does not require the use of sophisticated and expensive equipment.

Keywords: anaerobic power; sprinters; fatigue index; Wingate test; running-based anaerobic sprint test

1. Introduction

Anaerobic capacity is an important parameter for monitoring athletic performance. Anaerobic capacity describes an athlete's ability to sustain anaerobic activities. It refers to short-lasting efforts of the high-speed character for improvement and maintenance of the large muscular tension. The effort of sub-maximum and maximum intensity to which the athletes are subjected in sprint racing competitions (100 m, 200m and 400m), is mostly performed in anaerobic conditions and it demands the incurrence of the oxygenic debt, attaining even 18-22 litres in the case of 400-metre racing (Spencer & Gastin, 2001). There are several methods available to estimate anaerobic capacity during various types of sports: maximal accumulated oxygen deficit (MAOD), critical power (CP) concept, Wingate and Running-based anaerobic sprint test (RAST) (Noordhof, Skiba & de Koning, 2013; Adamczyk, 2011; Zagatto, Beck & Gobatto, 2009). The most often used tool to quantify the anaerobic capacity is the Wingate test (Jastrzebski, 1995). Several literatures are available that have applied the Wingate test mainly to assess the anaerobic metabolism of multi-sprint sports athletes (Gharvi, Dardouri, Haj- Sassi, Chamari & Souissi, 2015; Bencke, Damsgaard, Saekmose, Jørgensen, Jørgensen & Klausen, 2002; Davis, Brewer & Atkin, 1992). Although the Wingate test is easily applied and interpreted, it requires a set of resources, such as a cycle ergometer, computer and specific software that would detect the bicycle signal and, consequently, the analysis of results. Moreover, various detrimental physical responses like dizziness, headaches, nausea and vomiting and subsequent subject apprehension have been reported to occur after the Wingate test (Driss & Vandewalle, 2013).

RAST is one of the tests in which the natural field of play can be used for the evaluation of the power of anaerobic capacity and the estimation of the fatigue index (MacKenzie, 2005). Similar to the Wingate test, RAST also estimates the anaerobic power of different sports modalities which attribute intense and intermittent activities, such as basketball, team handball and performance on 100m, 200m and 400m sprint in track and field (Balciûnas, Stonkus, Abrantes & Sampaio, 2006; Paradisis, Tziortzis, Zacharogiannis, Smirniotou & Karatzanos, 2005; Roseguini, Ramos da Silva & Gobatto, 2008). RAST has the same advantages as the Wingate test albeit without high-cost equipment. It has been stated in earlier studies that the RAST-obtained anaerobic power is significantly correlated to the Wingate test (Zagatto, Beck & Gobatto, 2009; Zacharogiannis, Paradisis & Tziortzis, 2004). Another study has stated that the RAST is a relatively reliable, practicable field-based test which can be used by coaches to estimate their soccer player's level of average anaerobic power only (Burgess, Holt, Munro & Swinton, 2016). Although a previous study reported the effectiveness of RAST in the monitoring of the anaerobic power of sprinters in athletics (Adamczyk, 2011), the literature does not provide any validity and reliability of protocols for evaluation in track and field sprinters.

Therefore, the purpose of this study was to investigate the validity and reliability of RAST to evaluate anaerobic power performance in Wingate test in Indian male track and field sprinters. The research hypothesis of the study was that performing a field test (i.e. RAST) can replace the power performance in an anaerobic cycle ergometer (i.e. Wingate test) in Indian male track and field sprinters.

2. Material and Methods

2.1. Subjects

Thirty five (n=35) Indian male sprinters participating in 100m, 200 m and 400 m sprint racing (age: 20.3± 2.14 years; height: 171.64 ± 5.84 cm; body weight: 62.71± 6.45kg) without any known orthopedic, neuromuscular, or cardiovascular problems participated in the study. All players were recruited from Come and Play scheme of Sports Authority of India, New Delhi and they had an average of 12 months of training experiences. They were in the off-season period of play and were performing resistance and endurance training approximately 3 times per week. The investigation was approved by the Institutional Ethics Committee and all participants gave their written informed consent to participate in the study. The study is in agreement with the declaration of Helsinki of the World Medical Association. The athletes performed two testing sessions, all a minimum of two days and a maximum of seven days apart. Subjects were instructed to avoid vigorous exercise and alcohol consumption 48 hours before testing. Subjects were also instructed to ingest a meal 2 hours before testing and to maintain an adequate hydration level. A familiarization session was conducted before testing to give participants an opportunity to become accustomed to both protocols. Guidance regarding proper nutritional intake and hydration strategy was also provided at that time.

2.2. Procedures

During one of the testing sessions participants completed the RAST and during the other participants completed the Wingate. All testing sessions were carried out at the same time of day for each participant following a standardized warm up. At the beginning of all testing sessions clothed body weight (kg) was measured using digital stadiometer and weighing scales (SECA Gmbh, Germany) and standing height (cm) was recorded prior to the first test only. Prior to the testing sessions participants completed a familiarization session in which they performed both RAST and Wingate tests once.

2.3. Running-Based Anaerobic Sprint Test (RAST)

The RAST involved six 35-m maximal sprint efforts separated by 10 seconds of recovery (including deceleration phase). Infrared photocell gates (Speed Trap1; Brower Timing Systems, Draper, UT, USA) (placed precisely 35 m apart) were used to determine the duration of each sprint interval. Participants were verbally instructed as to when the recovery stage was complete after each bout. Before testing, participants were required to complete a 5-minute warm-up involving jogging and 2 short duration sprint efforts (3 seconds) at the end of the third and fifth minutes. After a 5-minute passive rest period, participants reported to a photocell gate, the test administrator counted down from 3, and on "GO," subjects were instructed to sprint as fast as they could to the opposite gate. The test administrator would then countdown from 5, and on "GO," the participant would sprint back to the first cell gate. This procedure was repeated until 6 sprints were completed, and the power in each sprint was then calculated by the formula i.e. Power = (Body mass × Distance ^{2})/Time ^{3} . Participants were allowed to accelerate for a maximum of 1 step before passing through the photocell gait. Sprint and recovery times were collected instantaneously on a PC via a National Instrument card (NI USB-6009, 14-bit resolution). Three testers were present at all times. One was in charge of the interfaced PC for recording sprint times, the second ensured that the recovery times were not exceeded, and the third monitored the portable metabolic telemetry system (VIASYS, Yorba Linda, CA, USA) and provided verbal encouragement to the subjects. After test termination, participants were required to continue sub maximal exercise (jogging) for 15 minutes to avoid injury.

2.4. Wingate Anaerobic Test (WAnT)

Initially the warm-up was performed for 5 minutes at 50 W. The warm-up period included two 3-second maximal sprints at the end of the third and fifth minutes. After a 5-minute rest period (passive recovery), the test administrator counted down from 3, and on "GO," participants were instructed to pedal as fast as they could. The Wingate consisted of exercise performed at maximal power for 30 secs with an external resistance corresponding to 75 g.kg^{-1} body weight. The cycle ergometer (Monark Ergomedic 894E, Sweden) protocol began without external resistance, which was added immediately after the test was initiated. Exercise time was recorded only after the test was initiated. The pedals were strapped to the feet and standing was not permitted during the test. Pedal revolution rate and power output were determined by Monark Anaerobic Test Software. The participants were required to pedal as fast as possible for 30 seconds and received verbal encouragement throughout the duration of the test. Values were obtained at 1 second intervals and after calculated the maximum (or peak) power in the initial 5-sec period, average power for 30 sec, minimum power in the last 5-sec period and the Fatigue Index (FI= peak power- minimum power/ peak power*100). Participants were required to continue cycling (50 W) for 15 minutes after test termination for active cooling down.

2.5. Statistical Analysis

Results are expressed as mean ± SD. Initially, the Shapiro Wilk test was used to analyze variable normality. All scores showed normality. Criterion validity was assessed with Pearson correlation coefficients to quantify the relationship between power values measured during the RAST and Wingate, whilst paired t-tests were used to compare differences in the magnitude of power values calculated. Correlation coefficients ranging from 0.4 to 0.59 were categorized as indicating a moderate linear relationship, 0.6 to 0.79 were categorized as strong, and 0.8+ were categorized as very strong (Evans, 1996). The relative reliability of test outcome variables measured from the RAST and Wingate was assessed by intra-class correlation coefficients (ICC) using a 2-way random model with the absolute agreement and 95 % CIs. ICC values were interpreted using the following guidance: 0.41 to 0.60 as moderate reliability, 0.61 to 0.80 as good reliability and 0.81 + as very good reliability (Altman, 1991). The absolute reliability of the same data was quantified using the 95 % limits of agreement (LOA) method originally described by Bland and Altman (1986). Linear regression analysis was also used using the difference b/w measurements as the dependent variable, and the average of the measurements as the independent variable to check the proportional biasness. Cronbach's alpha is used to measure the internal consistency of test outcome variables and a reliability coefficient of 0.70 or higher is considered "acceptable" in most social science research situations (Taber, 2018). All statistical analysis tests were performed using the statistical package for social sciences (SPSS) version 20.0. In all cases, a probability level of 95% ($p \leq 0.05$) was used for statistical significance.

3. Result

The various physical parameters like age, height, weight and BMI were tested for 35 male sprinters of mean (±SD) age of 20.3(± 2.14) years. The mean (±SD) height of the participants was seen to be 171.64(± 5.84) cms. The mean (±SD) weight of all the participants was seen to be 62.71(± 6.45) kg. The mean (±SD) BMI calculated for all the participants were 21.48(± 2.07). [Table 1].

Table 1: Mean and standard deviation of Physical Characteristics of athletes

Variable	Mean (N=35)	SD (±)
Age (yrs)	20.3	2.14
Height (cm)	171.6	5.84
Weight (kg)	62.7	6.45
BMI (kg.m^{-2})	21.5	2.07

Note: SD = Standard Deviation, BMI = Body Mass Index.

Paired t-tests revealed the maximum value [t (33) = -2.249, $p < 0.031$] and minimum value [t (33) = -2.779, $p < 0.009$] for anaerobic power were significantly greater in the RAST compared with the Wingate. Conversely, the average value obtained when measuring average power [t (33) = -0.997, $p = 0.326$] and fatigue index power [t (33) = 0.465, $p = 0.645$] were not significantly different between tests [Figure 1A and 1B].

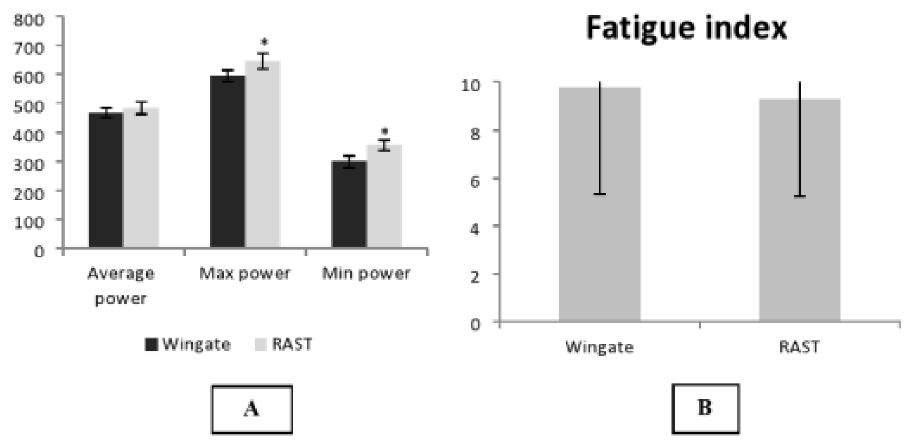

Figure 1 A) Average power (watt), Maximum Power (watt) and Minimum power (watt) recorded during RAST and Wingate B) Fatigue index (%) recorded during the RAST and Wingate. Data are mean ± SD. * P< 0.05

The RAST showed good relative reliability for average power, ICC = 0.628 (0.373 - 0.795: 95% CI) and moderate relative reliability for minimum power, ICC = 0.471 (0.163 - 0.695: 95% CI). Criterion validity was strong and positively significant for average power ($r = 0.644$, $p < 0.000$) and moderate and positively significant for maximum power ($r = 0.424$, $p = 0.013$) and minimum power ($r = 0.477$, $p = 0.004$). Internal consistencies for comparisons of power variables obtained from both the tests were calculated using Cronbach's alpha. The higher internal consistency was found only for average anaerobic power value ($\alpha = 0.772$). [Table 2]

Table 2: Intra-class correlation (ICC), Pearson's product moment correlation (r), Cronbach's alpha of the test variables of Wingate and RAST

Wingate vs RAST	ICC (95% CI)	Pearson's r	Cronbach's alpha
Maximum power (watt)	0.395 (0.071-0.644)	$0.424^{0.013}$	0.567
Minimum power (watt)	0.471 (0.163-0.695)	$0.477^{0.004}$	0.640
Average power (watt)	0.628 (0.373-0.795)	$0.644^{0.000}$	0.772
Fatigue Index (%)	-0.172 (-0.478-0.172)	$-0.173^{0.329}$	-0.415

Bland and Altman plots illustrating the distribution of the difference scores between tests for maximum, minimum and average power and fatigue index are illustrated in Figure 2 A, B, C and D. The upper and lower lines represent 95% confidential interval with means or bias ± 1.96 SD of the differences (Maximum power Limits of agreement (LOA): -373.74-250.34 watt; Minimum power LOA: -300.74-183.10 watt; Average power LOA: -204.23-171.44 watt and Fatigue Index LOA: -12.09-13.12). In these Bland-Altman analyses, linear regression analyses revealed that both means of differences and limits of agreement were found to be low in cases of average and minimum values of anaerobic power and fatigue index and the results were also not found to be statistically significant, resulting in good reliability [Table 3].

Table 3: Linear regression model for interpretation of Bland Altman Plots

Dependent Variable	Independent Variable	Unstandardized Coefficients (Beta)	Significance
Difference of Maximum power (watt) in Wingate vs RAST	Mean of Maximum power (watt) in Wingate vs RAST	-0.515	0.022
Difference of Minimum power (watt) in Wingate vs RAST	Mean of Minimum power (watt) in Wingate vs RAST	0.211	0.320
Difference of Average power (watt) in Wingate vs RAST	Mean of Average power (watt) in Wingate vs RAST	-0.273	0.102
Difference of Fatigue index (%) in Wingate vs RAST	Mean of Fatigue index (%) in Wingate vs RAST	0.246	0.561

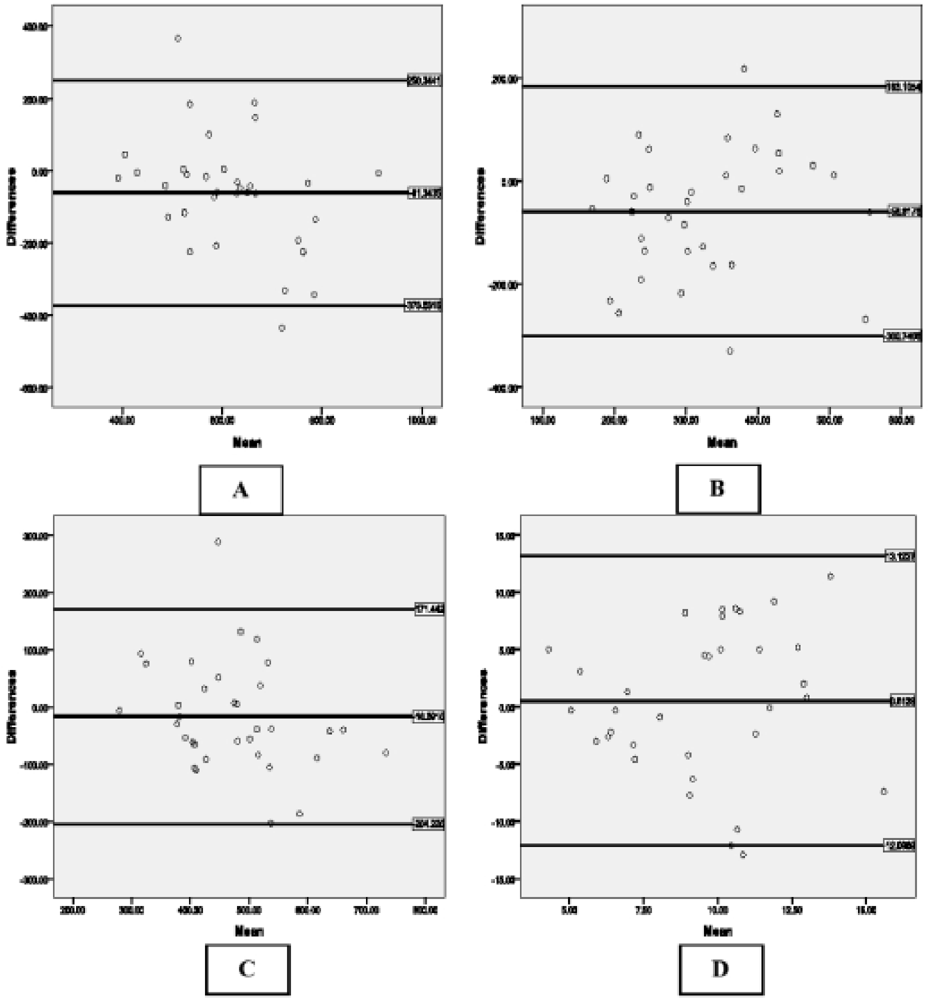

Figure 2: Bland and Altman plots illustrating the distribution of the difference scores between Wingate and RAST for A) maximum power, B) minimum power, C) average power and D) Fatigue index

4. Discussion

The intent of this study was to check the validity and reliability of the RAST in comparison to the Wingate test in male Indian track and field sprinters. The RAST is an adaptation of Wingate test for running, in which the time of exercise is very much related, but in the RAST, the time and effort are dependent on the physical capability of the subject to perform test. The RAST, as well as Wingate, can be used to assess muscular strength and the capacity of the legs to generate power. In sports such as soccer, basketball, and others, the use of this test is very interesting because of its reduced financial costs and easy application. It was also reported that RAST had validity and reproducibility with the Wingate test when applied to race athletes and football players (Roseguini, 2010). Previous research has reported mean scores of maximum anaerobic power of 614.43± 212.88 watts, minimum anaerobic power of 380.42± 131.72 watts, average anaerobic power of 483.65± 158.33 watts and fatigue index of 7.10± 3.67 of twenty-eight university level sprinters (100, 200 and 400 m runners; male=21 and female= 07) from the RAST (Paradisis, Tziortzis, Zacharogiannis, Smirniotou & Karatzanos, 2005). In addition, previous research has also reported large ranges in group peak power (599-810 W) and average power (451-665 W) values in basketball and soccer players (Balciûnas, Stonkus, Abrantes & Sampaio, 2006; Reza & Rastegar, 2012; Keir, Theriault & Serresse, 2013). This current study's group means for maximum, minimum and average anaerobic power lie within these ranges (645.1 ± 27 W, 356.1 ± 18.4 W and 482.7 ± 20.5 W).

The RAST was first examined by Zacharogiannis et al. (2004), who demonstrated significant correlations between the RAST and the Wingate for Peak power and Mean power variables (r = 0.82 and r = 0.75, respectively) and related that the RAST could be used to assess the anaerobic capacity and power. In our study, despite significant differences being found between the RAST and Wingate scores in maximum and minimum values of anaerobic power (Figure 1a), there were significant correlations between these two variables, but these correlations were not high (r = 0.424; and r = 0.477 respectively) (Table 2). Queiroga et al. (2013) found performance rates for Peak power and Mean power (W or W.kg-1) in Wingate test were significantly higher in cycling athletes than those obtained by RAST which was not in agreement with the findings of this study. Also, a previous study reported that the average value for peak power obtained from paired t-tests was significantly greater in comparison with the RAST (t (22) = 11.570, $p < 0.001$) (Burgess, Holt, Munro, Swinton, 2016). On the other hand, although there is no significant difference revealed in paired t-test in the average value of anaerobic power between the RAST and Wingate method (Figure 1a), but showed good relative reliability as verified by ICC test and strong and significant (P<0.000) positive correlation value and the higher internal consistency was found only for average anaerobic power value ($\alpha = 0.772$) (Table 2). The relative reliability of the RAST reported here is found to be less than the range previously reported for both average power (ICCs between 0.72 and 0.97) and maximum power (ICCs between 0.58 and 0.92) (Zagatto, Beck & Gobatto, 2009; Balciûnas, Stonkus, Abrantes & Sampaio, 2006; Reza & Rastegar, 2012).

We used Bland-Altman analysis to evaluate the absolute agreement between the two methods, which is the most commonly practiced approach to measuring agreement based on visual observation and to defining limits of agreement (Altman & Bland, 1983; Bunce, 2009; Williamson, Lancaster, Craig & Smyth, 2002). Analysis of agreement produced by the Bland-Altman´s test followed by linear regression analysis showed a lesser variability between the Wingate test and RAST for the anaerobic power parameters. Bias was very close to zero for variables like average power and fatigue index and test results were also found to be statistically not significant revealing test outcomes very likely to meet the expected agreement. The above result obtained from this study was not in agreement with the observation of Queiroga et al. (2013) where the researcher found a greater variability between the Wingate and RAST for all anaerobic power parameters and revealed that measurements obtained by tests failed to meet the expected agreement. In other studies, RAST results, too, could not be transferred to Wingate test results (Adamczyk, 2011). However, RAST has been validated as an evaluation procedure option for sports that utilize locomotion (Roseguini AZ, Ramos da Silva AS and Gobatto CA, 2008; Aziz & Teh, 2004).

As a limitation of the research, we can point to the lack of a test-retest method for the validity of the measured results which can be a direction for future research. Further, only absolute values of all anaerobic power parameters were studied for both Wingate and RAST for sprinters in this study, relative values with respect to their individual body weights may be incorporated in the future study to better assess the validity and reliability of both tests. We can also recreate the current investigation using a larger sample size with female athletic populations in Anaerobic Power tests.

5. Conclusions

In conclusion, the findings of this study have shown that the RAST is a relatively reliable, practicable field-based test which can be used by coaches to estimate their sprinter's level of average anaerobic power. The advantage of using the RAST to measure anaerobic power is that it allows the execution of movements more specific to sporting events that use running as their principal form of locomotion, and it can be easily applied by trainers and coaches in training.

Disclosure of Interest Statement
The authors declare that no competing financial interests exist.

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